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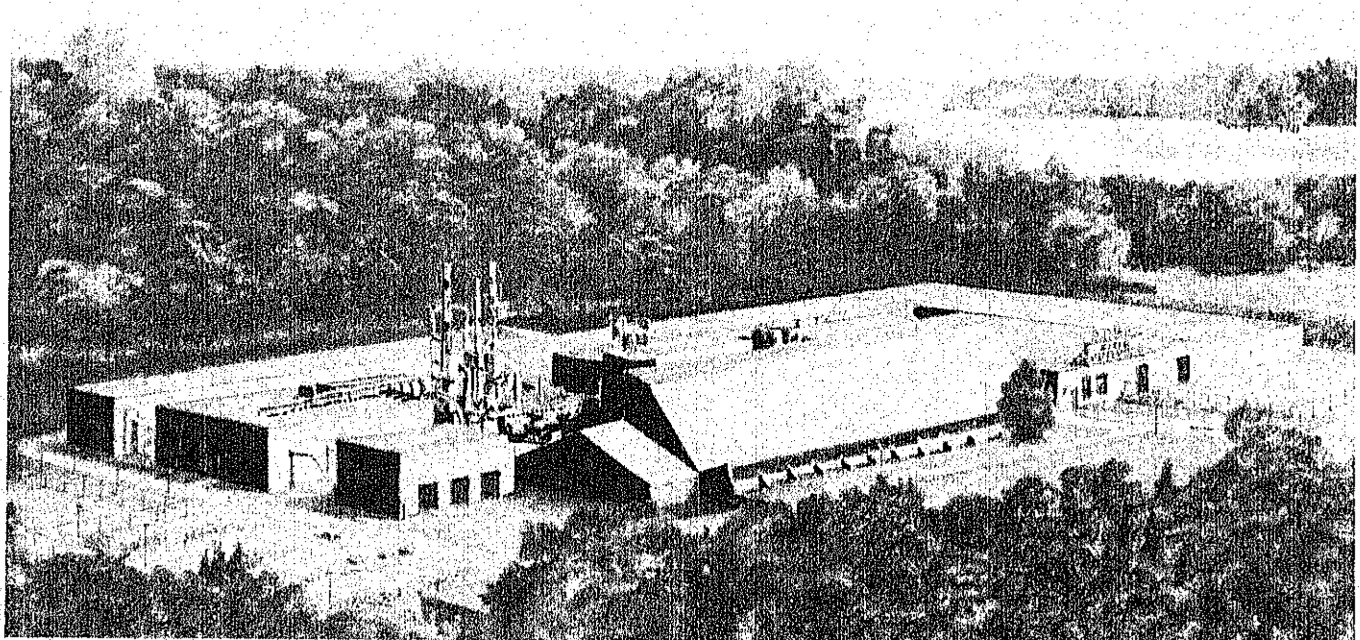
VENVAL

A Plywood Mill Cost Accounting Program

Henry Spelter

NONWOOD MANUFACT. COSTS: SEP 89 ($/MSM)

Grade\Thickness	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8
AAE	115.8	129.6	173.9	185.6	199.6	244.3	259.0	273.4
ABE	117.1	130.9	175.2	186.9	201.0	245.6	260.3	274.7
ACE	95.2	109.1	153.4	165.1	179.1	223.8	238.5	252.9
BB	110.1	123.9	168.3	180.0	194.0	238.7	253.3	267.8
BBO	110.1	123.9	168.3	180.0	194.0	238.7	253.3	267.8
BCE	95.8	109.6	153.9	165.6	179.6	224.3	239.0	253.4
AAI	113.9	127.7	168.2	179.9	193.9	234.8	249.4	263.8
ABI	115.2	129.0	169.5	181.2	195.2	236.1	250.8	265.2
ADI	91.4	105.2	145.8	157.5	171.5	212.3	227.0	241.4
BDI	92.0	105.8	146.3	158.0	172.0	212.9	227.5	241.9
CDX	66.8	73.9	144.4	125.9	139.8	175.0	189.6	203.9
CDX4	.0	.0	100.4	117.8	.0	.0	.0	.0
CDX3	.0	.0	89.6	.0	.0	.0	.0	.0
CDXPTS	82.5	89.6	130.1	141.6	155.4	190.7	205.3	219.6
CDUDL	82.5	89.6	130.1	141.6	155.4	190.7	205.3	219.6
CC	81.3	88.4	132.7	144.2	158.1	197.2	211.7	226.0



Abstract

This report documents a package of computer programs called VENVAL. These programs prepare plywood mill data for a linear programming (LP) model that, in turn, calculates the optimum mix of products to make, given a set of technologies and market prices. (The software to solve a linear program is not provided and must be obtained separately.) Linear programming finds the best solutions for a given set of circumstances. This paper illustrates and describes the software programs of VENVAL and its use in LP for softwood plywood mill operations.

Keywords: Plywood, cost accounting, linear programming, mill scheduling

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VENVAL
A Plywood Mill Cost Accounting Program

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Introduction

Linear programming (LP) has been used in many industries since its development in the early 1950s. It can be a valuable tool in plywood manufacturing where a host of material and product alternatives add up to a large number of choices. Among the references to LP in plywood manufacturing, Koenigsberg's paper (1960) is the earliest, describing the application of LP for product mix selection. A recent article by Seale and others (1989) describes the construction of detailed LP models. A package of computer programs, collectively called VENVAL, provides easy preparation of a LP optimization model for a softwood plywood mill. The objectives of this paper are to illustrate and describe the software programs of VENVAL and its use in LP for softwood plywood mill operations.

Scope of Model

To illustrate the purpose of VENVAL, an example of a simplified plywood production mix problem is presented as follows:

Production mix problem for a plywood mill

Maximize								
1. Objective function	100.0 Q(1)	+	45.0 Q(2)	−	75.0 L(1)	−	75.0 L(2)	
Subject to								Requirement
2. A veneer, 1/8 in.	1.0 Q(1)			−	0.5 L(1)			<0.0
3. C veneer, 1/10 in.			1.0 Q(2)			−	1.2 L(2)	<0.0
4. D veneer, 1/8 in.	2.0 Q(1)			−	3.0 L(1)			<0.0
5. D veneer, 1/10 in.			4.0 Q(2)			−	1.6 L(2)	<0.0
6. Press time	0.05 Q(1)	+	0.08Q(2)					<60.0
7. Log supply					1.0 L(1)	+	1.0 L(2)	<100.0 ft^3

where Q(1) and Q(2) are quantities of 3/8-in. AD-grade and 1/2-in. CD-grade plywood (1,000 ft^2 surface measure, or MSM), and L(1) and L(2) are quantities of logs peeled to 1/8 in. and 1/10 in. (100 ft^3 or Cunits).

The objective is to find the combination of output that maximizes profit, subject to limits on the availability of logs and press capacity. Line 1 is the objective function,

which contains the profit of each item sold and the cost of each input used. When multiplied by their respective quantities and summed, the result equals an estimate of the mill's gross profit.

Lines 2 through 5 indicate the veneer requirements, by grade, for each grade of plywood produced and the amount of veneer produced per unit of log used. The requirement that the sum of these be <0 means that the amount of veneer used must not exceed that recoverable from the logs.

Line 6 indicates the time required to press a given amount of each plywood grade and the amount of available press time. Line 7 constrains log use to that which is available.

The utility of LP model solutions depends partly on the realism of the formulation and partly on the quality of the data. Advances in personal computing power and software have made it possible to formulate and accurately solve large realistic models of plywood mills using desktop computers. Prior to these advances, only large mainframe computers could be used (Crockett 1988).

Regardless of the computing equipment used, data quality and accuracy remain critical requirements. Potential difficulties can be illustrated by referring to the example problem. Some data, such as veneer requirements by product (lines 2 to 5), are known from the panel constructions employed. To obtain other data, such as veneer recovery by log grade (lines 2 to 5) and press requirements by product (line 6), may require conducting mill studies. These studies may need to be repeated periodically if technology conditions in the mill change.

Most profit and cost values in the objective function frequently change. Profit, as used here, equals price less nonwood manufacturing cost. Price changes often but is readily determined from market reporting publications. Nonwood manufacturing cost, although more stable, is less easily determined. Mill analysts sometimes calculate an average unit cost for the mill, based on a 3/8-in. measure, and convert that to each veneer thickness. However, such calculations lead to significant errors if the product mix covers a wide range of veneer grades because cost is grade dependent (Seale and Wagner 1988). Therefore, inaccurate cost accounting can undermine the validity of LP solutions, even if other process parameters are accurate.

To address the need for a cost accounting system, VENVAL creates a framework to estimate manufacturing cost from aggregate mill cost data. In addition to providing an accounting mechanism, VENVAL contains programs to help calculate other variables in LP problems. It creates a nearly complete LP model that can be used with minimal additional work in a LP software program called LINDO[1] (Scientific Press, 540 University Avenue, Palo Alto, California 94301). Table 1 outlines the steps to formulate a LP model using VENVAL.

The VENVAL software runs on an IBM or compatible microcomputer. It requires a floppy diskette drive, 640K of machine memory, and MS-DOS version 2.0 (or higher). Some spreadsheet subprograms require LOTUS 123 software. If the LINDO LP software program is used, an 8087 coprocessor and access to a text editor that produces ASCII files are also required. If a LP software package other than LINDO is used, the

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Table 1—Steps to formulate a linear programming model using VENVAL

Step	Program	Output files created
1. Obtain mill cost and sales data	None	None
2. Enter mill cost and sales data	INPUT	salesfile1; costfile1
3. Reformat mill cost and sales data	COMBINE	salesfile2; costfile2
4. Get new price data, 3/8-in. basis	CONVERT.WK1	
5. Estimate unit cost and profit	VENVAL	LPFILE; INDDIS (contains cost reports)
6. Modify LP model parameters		LPMOD
–Green end capacity constraints	LATHCAP.WK1	
–Dryer capacity constraints	LATHCAP.WK1	
–Plugging capacity constraints	PLUGCAP.WK1	
–Pressing capacity constraints	PRESCAP.WK1	
7. Find optimum LP solution	LINDO	User-specified file

LP file produced by VENVAL may not be appropriate and the cost data may have to be transferred manually. Software for VENVAL can be obtained by contacting Henry Spelter at the Forest Products Laboratory (608–231–9200), Madison, Wisconsin. Appendix A contains programs, worksheets, and files, and the function of each, that are used in VENVAL.

Getting Started—INPUT and COMBINE

Inputs Required

Data are needed on manufacturing costs of 14 cost centers and product sales and volume. Manufacturing cost data are generally available from the mill's accounting department. For each cost center, data on volume of material handled and cost incurred are required, as shown in Table 2. Volume is based on the finished wood in the product. Volume differences among cost centers are a result of sales, purchases, and interplant transfers of semifinished materials. Cost includes each cost center's share of overhead.

Product sales volume (1,000 ft^2, 3/8-in. basis) and value data are placed in up to 19 grade and 8 thickness categories as follows:

Grade category	Grade includes
Sanded, Exterior	AA; AB; AC; BB; BBO&ES; BC; All exterior sanded shop grades
Sanded, Interior	AA; AB; AD; BD; All interior sanded shop grades
Rough	CDX; CDX(4 ply); CDX(3 ply); CDXPTS; Underlayment; CC; All rough shop grades

Thickness category (in.)	Thickness includes (in.)
1/4	1/4, 5/16
3/8	11/32, 3/8, 7/16
1/2	15/32, 1/2, 9/16
5/8	19/32, 5/8, 11/16
3/4	23/32, 3/4, 13/16
7/8	27/32, 7/8, 15/16
8/8	31/32, 8/8, 17/16
9/8	9/8 and thicker

Programs Used

The program INPUT is used to enter mill sales and cost data. Appendix B contains INPUT instructions. The program COMBINE rearranges the data compiled by INPUT into a consistent format so that the data can be used by VENVAL. Appendix C contains COMBINE instructions. If the price of plywood items need to be updated, the program CONVERT, to be explained later, can be used.

Obtaining Unit Cost and Profit—VENVAL

The two functions of VENVAL are (1) to calculate unit cost and profit for each thickness and grade of plywood and (2) to store these data in a file for use by a LP optimization software package.

Calculating Unit Cost and Profit

Inputs Required

Plywood manufacaturing cost for each grade is determined by calculating costs at each center. Then, VENVAL adds the constituents for each item based on assembly and grade. Data on process parameters at six cost centers are needed to translate the cost center data into cost for individual veneer or plywood grades.

1. Green end is the cost of processing veneer of any thickness relative to 1/10-in. veneer. This cost ratio is affected by the time needed to charge lathes and roundup blocks (additional time increases the cost ratio for thicker veneer), average block diameter relative to target core diameter (a wide cutting zone decreases cost ratio for thicker veneer), and peeled ribbon speed (a faster ribbon speed decreases the cost ratio for thicker veneer). Theoretical calculations should ideally be confirmed by observation. Program default values in this and the following five process parameters are based upon American Plywood Association data (APA 1984).

Table 2—Cost center data

Cost center	Volume ($\times 10^3$ ft^2, 3/8-in. basis)	Cost (US$)
1. Pond yard	119,400	429,240
2. Debarker	119,400	180,350
3. Green end	119,400	2,582,200
4. Drying	133,100	2,750,000
5. Veneer preparation	133,100	1,394,375
6. Layup/press	133,100	2,075,000
7. Panel trim	133,100	175,000
8. Panel patching	133,100	1,490,000
9. Warehousing	133,000	270,000
10. Selling	133,000	165,000
11. Oil and edge seal	0	0
12. Glue	133,100	1,200,000
13. Purchased veneer	13,700	2,001,000
14. Timber	119,400	13,200,000

2. Drying is the cost of processing veneer of any thickness relative to 1/10-in. veneer. The cost ratio depends on drying schedules and fill ratios (the proportion of the dryer space filled with veneer; high fill ratios decrease the cost ratio for thicker veneer).
3. Veneer preparation is the cost of processing veneer of any grade relative to A-grade veneer. Veneer preparation includes edge gluing and veneer plugging. The cost ratio depends on the average number of plugs per veneer grade and the likelihood of a veneer grade to be edge glued.
4. Layup and pressing is the cost of processing panels of any thickness relative to 1/4-in. panels. The cost ratio depends on the number of plies, press loading and unloading times, and press schedules.
5. Patching and sanding is the cost of patching and sanding panels of any grade relative to patching and sanding of BC- or BD-grade panels.
6. Veneer is the cost of veneer of any grade relative to CD-grade veneer.

Programs Used

The program VENVAL reads the data prepared by INPUT and COMBINE. Then, VENVAL prompts the user to supply the previous set of six process parameters. The program then calculates unit costs and automatically stores the results in a file called INDDIS. The cost of interest for the LP model is nonwood manufacturing cost, although all costs are estimated and saved for general information. Appendix D contains the printout of data tables using the cost center data (Table 2) and the program default process parameters.

Preparing the Linear Program Data File

A linear programming model consists of an objective function and a set of constraints. The VENVAL program prompts for information needed to set up the objective function and most of the constraints that constitute a plywood LP model.

Objective Function

The objective function is of the profit-maximizing type and is analogous to a bottom line profit and loss statement. Its revenue-generating elements are (1) profit from each plywood item and (2) revenue from by-product sales (chips, cores). Its cost-incurring elements are (1) timber purchases, (2) veneer purchases, and (3) veneer upgrading.

Profit is the price of the plywood item less its nonwood manufacturing cost, except veneer preparation (upgrading). Other cost-incurring elements; that is, wood, veneer, and veneer preparation, appear directly in the objective function.

Input Required — The user specifies a price discount ratio. The price discount ratio is used to determine a second profit for each item. The first profit is based on the price from the mill report (or from a current price list, see Updating Prices—CONVERT). The second profit is based upon this price discounted by the price discount ratio. Volume of an item up to its historical level, as entered from mill sales reports, is valued at the higher profit. Additional amounts that the model may want to specify are valued at the lower profit. For a discussion of this feature and a guide to selecting discount values, see General Considerations in LP Optimization.

Program Used — The VENVAL program sets up the objective function.

Constraints

Inputs Required — The VENVAL program prompts for the following data:

1. Ratio of the planning period to the period from which the sales and cost data were obtained—for example, if sales data were for an annual period and the planning period was for 1 month, the ratio would be 1/12 or 0.083.
2. Number of log categories—the maximum is four. After entering the number of log categories, enter each log's cost per 100 ft^3.
3. Purchase cost of green veneer—price is per 1,000 ft^2, surface basis.
4. Selling value of residues—cores are expressed in value per core, chips per ovendried ton.
5. Minimum volumes—may be specified to control the model solution. If this option is specified, the name of an item and its historical volume are printed (after adjustment for planning period by (1) above). The user then enters the desired minimum volume.

Program Used — The VENVAL program sets up these constraints.

Linear Program Model Preparation—LPFILE

The VENVAL program creates a file called LPFILE and stores data generated in a format ready for use with a LP software program called LINDO. Its contents are as follows:

1. A line indicating the maximizing nature of the problem "`MAX)`".
2. The objective function containing (a) profit of 128 products at high and low values, (b) cost of up to four classes of logs, (c) cost of four veneer upgrading operations, (d) cost of up to four grades of purchased veneer, and (e) revenue from two by-products. The objective function requires no additional user modification.

3. A line indicating the start of the constraints to which the objective function is subject "ST)".

4. Equations specifying minimum production volumes. The number of equations corresponds to the number of restrictions specified during VENVAL. These equations require no additional user modification.

5. Equations specifying maximum volumes that can be valued at the highest profit level. The number of equations corresponds to the number of items that were produced in the accounting period. These equations require no additional user modification.

6. Three cost equations accounting for log, veneer, and veneer preparation costs. These equations require no additional user modification.

7. Fourteen equations representing veneer requirements of a particular grade and thickness of plywood. **These equations need to be modified further** (see information following this list).

8. A line indicating the end of the model "END)".

9. A line returning control to the optimization software "LEAVE)".

In addition to modifying item 7, several additional constraints must be supplied. To facilitate this, the necessary additional constraints in the required format were stored in a file called LPMOD. The user needs only to merge the contents of LPMOD with LPFILE. Parameter values of the various constraints, however, must first be customized to make them consistent with the mill's situation. A text editor such as PC-Write or WordPerfect can be used to make changes in LPMOD and LPFILE. The required changes in LPMOD are as follows:

1. Modifying veneer requirement equations. The last 14 equations in LPFILE specify the requirement for each of the 14 thicknesses and grade combinations of veneer. For example, the constraint for 1/6-in., C-grade veneer appears as

   `C6)` (this nonexecutable label identifies the constraint)

   ```
   1.CDX312H + 1.CDX312L < 0.0
   ```

   This states that for one unit of CDX grade, three-ply, 1/2-in.-thick plywood, one unit of C-grade, 1/6-in.-thick veneer is required (for variable names, see App. E; for panel constructions, see App. F). The `H` and `L` suffixes indicate volumes of the same item priced at the high and low profit margins previously described (Obtaining Unit Cost and Profit—VENVAL). This constraint is incomplete because the veneer supply and other veneer demand components are missing. Sources of supply are (a) peeled logs, (b) open market veneer purchases, and (c) upgrading of D-grade veneer. Other demand is caused by downgrading C-grade veneer to D-grade. The equation must be modified to include these elements. The following would apply for a case where two logs are used:

   ```
   C6)
       1.CDX312H + 1.CDX312L + 1.YCD6 - 1.YDC6
       - 2.5SLOG06 - 2.7MLOG06 - .5PCD6 < .0
   ```

   where `YCD6` represents the conversion of a unit of C-grade veneer to D; `YDC6` represents the reverse conversion; `2.5SLOG06` and `2.7MLOG06` represent the recoveries (1,000 ft^2, surface measure, per 100 ft^3 of log) of dried, trimmed, C-grade, 1/6-in.

veneer from the two log grades (`S` for small, `M` for medium); and `.5PCD6` represents the share of purchased 1/6-in. CD-grade veneer (0.5) that meets C-grade veneer standards. Users, of course, should use their own parameter estimates. Note the convention that veneer demand is preceded by a plus and veneer supply by a minus. The equation has to be less than or equal to zero so that veneer demand does not exceed supply.

Similar changes are made to each of the 14 equations. The veneer constraints in LPMOD are properly formatted and the user needs only to change the recovery parameters to the appropriate mill values using a text editor.

2. Adding machine capacity constraints. Any mill has a finite amount of productive capacity. Constraints must be incorporated to adequately describe the mill environment. These constraint equations are located after the veneer supply constraints. Four machine centers are characterized in LPMOD: (1) green end, (2) drying, (3) plugging, and (4) pressing. More machine centers could be developed, but the effort may not be worth the gain because of the interdependence of subcenters. For example, the green end could be decomposed into the lathe, clipper, and stacker but little would be gained because none could function for long independently of the others.

   The green-end machine use is expressed in hours needed to process 100 ft^3 of logs. The spreadsheet LATHCAP.WK1 calculates such parameters for given log sizes. The maximum number of elements in the constraint equals the number of log types used times the number of thicknesses cut. For example, four log types and four veneer thicknesses equals 16 elements. The right-hand side of the constraint (machine hours available) is the product of the number of days in the period, the number of effective hours operated per day, and the number of green-end lines.

   The two classes of materials processed by the dryer are veneer peeled by the mill and veneer purchased. For veneer peeled by the mill, machine use is expressed in hours needed to process 100 ft^3 of logs. For veneer purchased, machine use is expressed in hours needed to process 1,000 ft^2 of veneer (surface measure). The spreadsheet LATHCAP.WK1 calculates parameters for both classes of materials. The number of elements in the constraint is the same as for the green end, plus four purchased veneer grades. The machine hours available is the product of the days in the period, the effective hours operated per day, and the number of dryers.

   The plugging machine use is expressed in hours needed to process 1,000 ft^2, surface measure, of veneer. The spreadsheet PLUGCAP.WK1 can be used to estimate parameters. The number of machine hours available is the product of the number of days in the period, the number of effective hours operated per day, and the number of pluggers.

   Press use is expressed in hours needed to process 1,000 ft^2, surface measure, of panels. The spreadsheet PRESCAP.WK1 can be used to estimate parameters for various panel thicknesses. The number of equation elements is twice the number of plywood items made (128) because each item appears twice in the objective function with different profits. The number of machine hours available is the product of the number of days in the period, the number of effective hours operated per day, and the number of presses.

3. Adding log supply constraints. Another practical mill constraint is the supply of logs available for processing during the period. The constraints for log availability follow those for the machines. There are as many constraints as there are log types

(up to four). Each constraint has four elements (for the four thicknesses that can be peeled). Each equation has the following format as illustrated for log type "S":

```
SLOGS)

   1.SLOG10 + 1.SLOG08 + 1.SLOG06 + 1.SLOG16 < 1125
```

where SLOG___ indicates the S log class (S is small, M is medium, L is large, X is extra large) that can be peeled to one of the four thicknesses (1/10, 1/8, 1/6, 3/16 in.), and 1125 indicates the volume in 100 ft^3 available for the planning period. The only part of these constraints that needs changing is the volume of wood available (e.g., 1125).

4. Adding purchased veneer constraints. Another option for some mills is to augment internally generated veneer by purchases from other vendors. The amount of veneer available represents another constraint and is incorporated following the log supply constraints. The four constraints for the four veneer classes are AB 1/10-in., AB 1/8-in., CD 1/10-in., and CD, 1/6-in. For the AB 1/10-in. class, the constraint might be as follows:

```
PAB10)

    1.PAB10 < 2500
```

where PAB10 is the name of the variable (other variable names are PAB8, PCD10, and PCD6) and the number 2500 is the volume available, in 1,000 ft^2 surface measure. Alter the volume values in LPMOD directly. In some cases, contractual agreements might oblige a mill to purchase a minimum amount of veneer, which would have to be incorporated by means of a similar constraint specifying a minimum volume.

5. Adding veneer conversion constraints. A unique feature of plywood manufacturing is that the raw material (veneer) can be upgraded from its natural condition by plugging defects. Alternatively, a higher grade of veneer can be used in place of a lower grade. The constraints on how much veneer can be thus transformed follow the constraints on purchased veneer. The convention again is to use a plus sign to indicate demand and a negative sign to indicate supply. Demand includes both upgrading and downgrading veneer. Supply is from peeled logs and purchased veneer. An example of the equation for B-grade, 1/10-in. veneer with three grades of logs peeled follows:

```
B10CON)

    - .029SLOG10 - .103MLOG10 - .346LLOG10+ 1.YBA10

    + 1.YBC10 - .7PAB10 < 0
```

where the first three terms represent the recovery of dried, B-grade veneer in 1,000 ft^2 surface measure, per 100 ft^3 of logs; YBA10 and YBC10 represent the conversion of a unit of B-grade veneer into A or C, respectively; and .7PAB10 represents the share of purchased AB-grade veneer that falls into the B category. The requirement that the equation be no greater than zero states that demand cannot exceed supply. There are 10 veneer conversion constraints.

6. Adding by-product constraints. Saleable by-products generated in plywood manufacturing include cores and chips. How much can be sold depends on the amount and kind of logs peeled. By-product constraints follow those for veneer conversion. As before, a plus indicates demand (sales) and a minus indicates supply (production). Core supply is expressed in number of cores per 100 ft^3 of log, chip supply is

in ovendried tons per 100 ft^3 of log. For example, if only the S log type were peeled, the equations for cores and chips would be as follows:

```
CORES)
     - 20.2SLOG10 - 20.2SLOG08 - 20.2SLOG06 - 20.2SLOG16
     + 1.CORES < 0.0
CHIPS)
     - .141SLOG10 - .138SLOG08 - .135SLOG06 - .133SLOG16
     + 1.CHIPS < 0.0
```

7. Adding panel production accounting constraints. These constraints do not functionally affect the solution but are added to account for the volume of production that falls into various categories, such as sanded or unsanded.

Running the Model—LINDO

After parameter values of the previous constraints have been customized in LPMOD, they need to be added to the LPFILE file. This is accomplished by (1) deleting the block of incomplete veneer requirement constraints in LPFILE using the text editor and (2) merging the contents of the updated LPMOD into LPFILE. Figure 1 summarizes this procedure. Note that this procedure must be repeated after each VENVAL run because a new LPFILE is created each time.

The contents of LPFILE and LPMOD are tailored for use with the LINDO software program. If the user has LINDO, then the program is ready. Type `LINDO` to activate the program. Then, enter `TAKE LPFILE` (or, if the file was renamed, the new filename) for the model to be read in. Before solving, enter DIVERT filename so that the output is saved into a file. Then, type `GO` to initiate the algorithm. For other commands, consult the LINDO manual.

The final step is to analyze the results that were diverted from LINDO. The output is voluminous and complex. A program called READ was prepared to extract the most important information from the file and to arrange it in a readable format. Appendix G contains a printout of this format.

Updating Prices—CONVERT

Plywood prices change continually and should be updated before each run. The easiest way to update is to enter the data manually into the selling price file created by the COMBINE program using a text editor. However, price is required to be on a 3/8-in. basis, which is not the normal manner in which plywood price is reported. A spreadsheet program called CONVERT is included to make the conversions from surface measure to 3/8-in. basis. When the updated price data are entered, VENVAL recalculates profit margins, as before.

Log and purchased veneer prices are entered when the VENVAL program prompts the user to supply the information.

General Considerations in LP Optimization

Linear programming solutions can specify product mixes that vary drastically from normal mill production. This is because the algorithm proceeds on the assumption that any amount of a product can be marketed at the specified profit. If this assumption is true, then the LP solution is valid. However, the likely effect of overproduction of an item would be a decrease in its profit because its price would decrease. On the other hand, scarcity of a product because of underproduction would increase its profit because its price would increase. The LP models do not take into

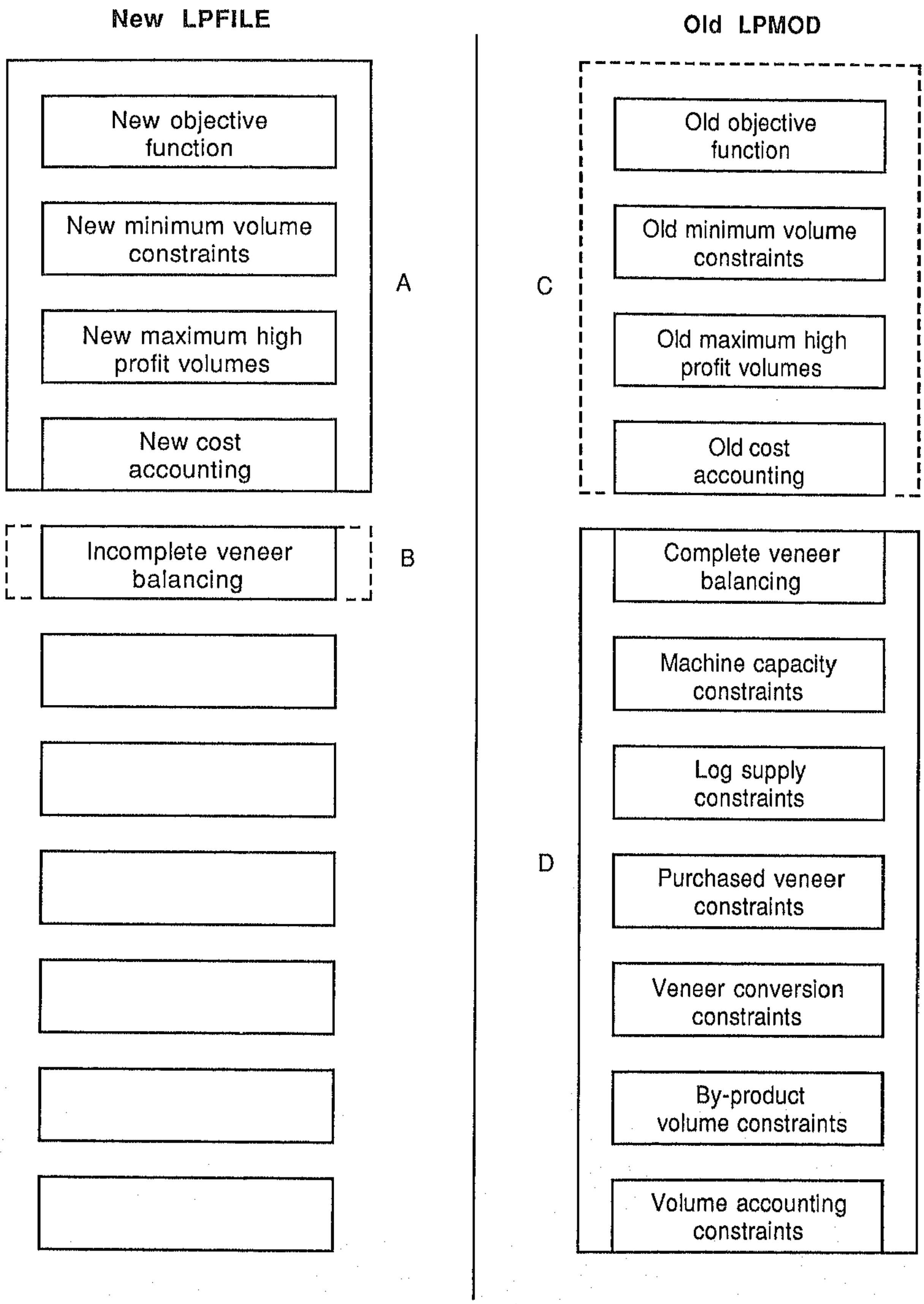

Figure 1—To update LPFILE, delete block (B) from new LPFILE, delete block (C) from old LPMOD and append block D to A.

account such pricing variability even though with each change in price, the optimum solution could change.

Analysts understand these factors and try to overcome them by specifying minimum and maximum amounts of a product that may be produced. This is an onerous and imprecise procedure at best. An alternative is to use the previous production mix (obtained from mill records, see Getting Started—INPUT and COMBINE) as a starting point and allow the current profits to be applied only up to the level at which each item was actually produced. Extra amounts that the model may want to specify are discounted by a factor specified by the user. The model is indirectly constrained by finding lower profits for items produced in excess of historical volumes, but the model may still specify that amount of production if it finds this profitable at the lower profit level.

This raises the question of what would be an appropriate discount factor. Its specification is a matter of judgment, taking into account many variables, such as potential price, inventory effects, and customer relations. However, one potential guide is how much an item would be discounted if it had to be sold at the price of the next lowest grade. For example, the discount factor from 1/2-in. CC-grade to 1/2-in. CD-grade plywood in September 1989 was 7 percent. Several such calculations may provide a reasonable guide for what value to assume for the price discount ratio.

Table 3 shows alternative LP solutions (1 to 4) for a mill that in the prior period produced the mix indicated in the "Actual production" column.

Solution 1 was obtained by letting the model find an unconstrained solution with one profit assumption for each item. It selected just three grades, a mix heavily focussed on seldom used specialty items.

In solution 2, selling prices of items produced in excess of historical amounts are discounted by 8 percent. This increases the number of items specified to 11, but the solution remains improbable as many limited volume items continue to be over specified in the mix.

Solution 3 imposes some minimum volume requirements on the product mix. These minimums might reflect orders on hand, or represent a consensus as to what is feasible from the marketing viewpoint. The solution now becomes more balanced, but still contains an anomaly in that one item (3/8-in.-thick CC-grade veneer) is specified in excess by a factor of more than 150.

Solution 4 derives from the imposition of constraint on the maximum volume that may be produced of this item. This could be done by specifying the constraint while in LINDO or using the text editor in LPFILE. The constraint is similar to the minimum volume constraints except the inequality sign is reversed. For example,

```
CCXX38H + CCXX38L < 25.0
```

The result is displayed under solution 4. Although some items continue to be specified in excess of their historical amounts, the excesses are becoming smaller and are, at any event, valued at the discounted price. Thus, solution 4 is more realistic, requiring at most a few iterations to achieve an acceptable mill schedule and output mix.

Table 3—Alternative LP solutions for sample mill

	Values (×10³ ft², surface measure)				
	Actual production[a]	Alternative solutions[b]			
		1	2	3	4
Items produced[c]					
Sanded AA-grade, exterior					
8/8	0.1				0.1
Sanded AB-grade, exterior					
1/4	52.1			35.0	35.0
1/2	107.7			80.0	80.0
3/4	231.2			225.0	225.0
8/8	5.6	943.5	9.4	5.6	5.6
Sanded AC-grade, exterior					
1/4	912.0			700.0	700.0
3/8	476.4			500.0	500.0
1/2	706.5			500.0	500.0
5/8	193.1			150.0	150.0
3/4	652.0			450.0	450.0
8/8	33.5		33.5		33.5
Sanded, BB-grade					
5/8	802.9		802.9	779.0	802.9
3/4	229.6		229.6	229.6	229.6
Sanded AB-grade, interior					
1/2	58.6			33.0	33.0
3/4	178.9			150.0	150.0
7/8	0.4	1,490.7	882.7	0.4	329.0
8/8	0.8		0.8	0.8	0.8
Sanded AD-grade, interior					
1/4	256.9			125.0	125.0
1/2	147.8			125.0	125.0
3/4	141.5			100.0	100.0
8/8	0.5		0.5		0.5
Rough CD-grade, exterior					
5/16	76.7			50.0	50.0
3/8	414.4			300.0	300.0
1/2	951.1			450.0	450.0
5/8	402.1			400.0	400.0
3/4	333.5			250.0	250.0
Rough CC-grade					
3/8	12.1	4,280.2	5,775.0	1,864.2	25.0
1/2	38.4		38.4	38.4	462.4
5/8	13.3		13.3	13.3	207.0
3/4	13.0		13.0	13.0	13.0

(continued next page)

Table 3—Alternative LP solutions for sample mill—con.

	Values (×10³ ft², surface measure)				
	Actual production[a]	Alternative solutions[b]			
		1	2	3	4
Output (3/8-in. measure)	11,086.2	10,272.7	9,849.0	9,996.9	9,941.9
		Machine utilization (percent)			
Green end	NA	95.0	96.0	93.0	91.0
Dryers	NA	100.0	95.0	100.0	100.0
Plugger	NA	83.0	95.0	100.0	99.0
Presses	NA	69.0	65.0	63.0	63.0
		Profit (×10³ US$)			
	NA	446.4	288.6	82.0	72.9

[a]NA, not applicable.

[b]Note: Alternative solution 1 refers to an unconstrained LP solution; alternative 2 is based on two profit levels for each item; alternative 3 is based on minimum volume constraints for each item of output; alternative 4 adds a maximum volume constraint on the item produced in excess.

[c]Thicknesses are in inches.

The reduction in the number of constraints is one of the chief benefits of using the two-profit approach employed by VENVAL. Instead of two constraints per product, only lower limits generally need to be used with a few upper limits only for outliers. With fewer constraints, the chance of specifying an infeasible solution is reduced. An infeasible solution is one where contradictory constraints lead to an illogical specification, such as when a minimum for an item is greater than its maximum. For example, Y has to be less than 10, and simultaneously Y has to be >15. A more subtle variation is when a minimum volume specification requires more resources (for example, more logs, dryer capacity) than are available.

References

APA. 1984. Annual cost report for the western plywood industry—year 1983. American Plywood Association, Tacoma, WA.

Crockett, Randy. 1988. Compare mill options with desktop computer. Forest Industries. 115(9): 30–31.

Koenigsberg, Ernest. 1960. Applying linear programming to the plywood industry. Forest Products Journal. 20(9): 481–486.

Seale, R.D.; Wagner, F.G. 1988. Traditional basis creates inaccurate cost estimates. Forest Industries. 115(8): 30–31.

Seale, R.D.; Wagner, F.G.; Livingston, T.W. 1989. A softwood plywood linear programming matrix structured for a microcomputer environment. Forest Products Journal. 39(1): 33–38.

Appendix A—Programs, Worksheets, and Files

Table 4 contains the programs, worksheets, and files used in VENVAL. The function of each is also given.

Table 4—Programs, worksheets, and files of VENVAL

	Function
Program.name	
1. INPUT.EXE	Used to enter mill sales and cost analysis data
2. COMBINE.EXE	Puts sales and cost analysis data into a consistent format
3. VENVAL.EXE	Calculates unit cost and profit, and initiates LPFILE
4. READ.EXE	Summarizes LP solution
Worksheet.name	
1. CONVERT.WK1	Translates plywood price from surface measure to 3/8-in. basis
2. LATHCAP.WK1	Estimates green end and dryer process rates per cubic unit of log
3. PLUGCAP.WK1	Estimates plugging process rates per 1,000 ft^2 of veneer
4. PRESCAP.WK1	Estimates press process rates per 1,000 ft^2 of panel
File.name	
1. DEFLT	Contains default process parameter values used by VENVAL
2. LPFILE	Created by VENVAL and contains outline of LP model
3. LPMOD	Contains remaining portion of LP model that must be appended to LPFILE to complete structure. The parameters next to each variable should be modified to reflect user's particular situation
4. TEMPLATE	Used by COMBINE to order sales analysis data into a consistent format

Appendix B—Entering Mill Sales and Costs

Sales Analysis Data

1. Type `INPUT`.
2. When prompted, name the file where the data will be stored.
3. In response to next prompt, specify whether value data represent total value or value per 1,000 ft^2 (3/8-in. basis).
4. Enter data. Format is (a) product name, (b) thickness, (c) volume, and (d) value. Enter each element in the field as indicated in the heading. Enter one of the following for product name:

Exterior grade, sanded	Interior grade, sanded	Unsanded grades
AAE	AAI	CDX
ABE	ABI	CDX4 (4 ply)
ACE	ADI	CDX3 (3 ply)
BB	BDI	CDXPTS (plug and sand)
BBO (oiled and sealed)	SSI (shop and rejects)	CDUDL (underlayment)
BCE		CC
SSE (shop and rejects)		RSS (shop and rejects)

Enter thickness in fractions (e.g., 1/2 is `1/2`, etc.). For a thickness not a multiple of 1/8 in., enter one of the following:

Thickness category (in.)	Thickness includes (in.)
1/4	1/4, 5/16
3/8	11/32, 3/8, 7/16
1/2	15/32, 1/2, 9/16
5/8	19/32, 5/8, 11/16
3/4	23/32, 3/4, 13/16
7/8	27/32, 7/8, 15/16
8/8	31/32, 8/8, 17/16
9/8	9/8 and thicker

Enter volume in thousands (e.g., 15,000 ft^2 is entered as `15.0`).

Enter value in actual amounts (e.g., 1,000 is `1000`).

5. After entering these data, enter `END 0 0 0`, with an entry in each field.
6. Data entered will be printed back for error checking and correction.
7. Proceed to enter cost data.

Cost Analysis Data

1. In response to prompt, name the file where the data will be stored.
2. Enter volume and value for each cost center as prompted. Volume is based on finished wood equivalent in units of a million (e.g., 15,000 is entered as `.015`). Cost is entered in thousands (e.g., 1000 is `1.0`).
3. If a value was entered incorrectly, type the line number after all entries have been displayed and enter correct value.
4. If a U.S. West Coast mill, enter price (in dollars per 1,000 board feet) of each timber grade together with its share of the total log mix. If not a West Coast mill, enter average log cost (in dollars per 100 ft^3).
5. Enter total revenues from residues (in units of $1,000).
6. If a U.S. West Coast mill, enter product recovery (in either 1,000 ft^2 or 1,000 board feet). If not a West Coast mill, enter recovery in 1,000 ft^2 per 100 ft^3.
7. Program terminates.

Appendix C—Consolidating Mill Data

1. Type `COMBINE`.
2. In response to prompt, name the file(s) where the sales analysis data are stored. Then type `NONE`.
3. Enter name of file to contain the formatted sales analysis data.
4. In response to prompt, name the file(s) where the cost analysis data are stored. Then, type `NONE`.
5. Enter the name of the consolidated file containing the formatted cost analysis data.
6. Program terminates.

Appendix D—Printout of VENVAL-Produced Reports

Tables 5 to 12 are actual computer program printout files using the cost center data in Table 2 and the program process parameters.

Table 5—Volume of sales for September 1989

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8	TOTAL
AAE	54.	3.	68.	53.	122.	0.	2.	0.	303.
ABE	417.	355.	1724.	639.	5551.	0.	179.	0.	8865.
ACE	7299.	5719.	11309.	3863.	15655.	0.	1071.	0.	44916.
BB	0.	0.	0.	16065.	5513.	0.	0.	0.	21578.
BBO	0.	0.	0.	0.	0.	0.	0.	0.	0.
BCE	121.	63.	89.	62.	512.	0.	0.	0.	847.
AAI	3.	0.	0.	0.	42.	0.	0.	0.	45.
ABI	186.	66.	878.	1258.	3994.	5.	8.	0.	6394.
ADI	1474.	615.	2212.	997.	3159.	0.	5.	0.	8463.
BDI	74.	57.	101.	9.	119.	0.	0.	0.	359.
CDX	764.	4975.	15224.	8045.	8008.	0.	0.	0.	37016.
CDX4	0.	0.	564.	0.	0.	0.	0.	0.	564.
CDX3	0.	0.	0.	0.	0.	0.	0.	0.	0.
CDXPTS	0.	0.	0.	0.	0.	0.	0.	0.	0.
CDUDL	0.	0.	0.	0.	0.	0.	0.	0.	0.
CC	0.	145.	614.	266.	311.	0.	0.	0.	1336.
RSS	0.	0.	0.	0.	0.	0.	0.	0.	0.
SSE	0.	0.	0.	0.	0.	0.	0.	0.	0.
SSI	685.	436.	222.	419.	552.	5.	29.	0.	2346.
TOTAL	11077.	12434.	33004.	31677.	43537.	10.	1296.	0.	133034.

Table 6—Value of sales for September 1989

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8	TOTAL
AAE	18.	1.	17.	13.	28.	0.	1.	0.	78.
ABE	132.	94.	421.	149.	1230.	0.	42.	0.	2068.
ACE	1704.	1193.	2266.	762.	2973.	0.	221.	0.	9120.
BB	0.	0.	0.	3441.	1161.	0.	0.	0.	4602.
BBO	0.	0.	0.	0.	0.	0.	0.	0.	0.
BCE	28.	12.	17.	11.	95.	0.	0.	0.	162.
AAI	1.	0.	0.	0.	9.	0.	0.	0.	10.
ABI	56.	17.	206.	283.	834.	1.	2.	0.	1400.
ADI	327.	122.	419.	185.	560.	0.	1.	0.	1614.
BDI	15.	11.	18.	1.	20.	0.	0.	0.	65.
CDX	118.	771.	2301.	1200.	1188.	0.	0.	0.	5578.
CDX4	0.	0.	82.	0.	0.	0.	0.	0.	82.
CDX3	0.	0.	0.	0.	0.	0.	0.	0.	0.
CDXPTS	0.	0.	0.	0.	0.	0.	0.	0.	0.
CDUDL	0.	0.	0.	0.	0.	0.	0.	0.	0.
CC	0.	26.	114.	47.	54.	0.	0.	0.	241.
RSS	0.	0.	0.	0.	0.	0.	0.	0.	0.
SSE	0.	0.	0.	0.	0.	0.	0.	0.	0.
SSI	124.	60.	36.	70.	85.	1.	5.	0.	381.
TOTAL	2523.	2360.	5797.	6164.	8238.	2.	272.	0.	25400.

Table 7—Selling prices for September 1989

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8
AAE	222.6	270.8	338.4	422.7	458.4	.0	626.4	.0
ABE	210.5	264.5	325.6	389.2	443.2	.0	619.2	.0
ACE	155.6	208.6	267.2	328.8	379.8	.0	551.2	.0
BB	.0	.0	.0	357.0	421.4	.0	.0	.0
BBO	.0	.0	.0	.0	.0	.0	.0	.0
BCE	152.5	190.4	250.5	297.2	369.4	.0	.0	.0
AAI	207.9	.0	.0	.0	426.8	.0	.0	.0
ABI	202.2	255.1	313.6	375.3	417.6	553.2	590.9	.0
ADI	147.7	197.9	252.5	309.7	354.6	.0	536.5	.0
BDI	137.8	185.1	232.7	260.0	337.0	.0	.0	.0
CDX	127.8	154.9	201.6	248.7	296.8	.0	.0	.0
CDX4	.0	.0	193.2	.0	.0	.0	.0	.0
CDX3	.0	.0	190.0	.0	.0	.0	.0	.0
CDXPTS	.0	.0	.0	.0	.0	.0	.0	.0
CDUDL	.0	.0	.0	.0	.0	.0	.0	.0
CC	.0	182.5	246.8	297.0	346.2	.0	.0	.0
RSS	.0	.0	.0	.0	.0	.0	.0	.0
SSE	.0	.0	.0	.0	.0	.0	.0	.0
SSI	181.8	137.5	162.4	166.4	154.0	128.8	174.2	.0

Table 8—Nonwood manufacturing costs for September 1989

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8
AAE	115.8	129.6	173.9	185.6	199.6	244.3	259.0	273.4
ABE	117.1	130.9	175.2	186.9	201.0	245.6	260.3	274.7
ACE	95.2	109.1	153.4	165.1	179.1	223.8	238.5	252.9
BB	110.1	123.9	168.3	180.0	194.0	238.7	253.3	267.8
BBO	110.1	123.9	168.3	180.0	194.0	238.7	253.3	267.8
BCE	95.8	109.6	153.9	165.6	179.6	224.3	239.0	253.4
AAI	113.9	127.7	168.2	179.9	193.9	234.8	249.4	263.8
ABI	115.2	129.0	169.5	181.2	195.2	236.1	250.8	265.2
ADI	91.4	105.2	145.8	157.5	171.5	212.3	227.0	241.4
BDI	92.0	105.8	146.3	158.0	172.0	212.9	227.5	241.9
CDX	66.8	73.9	144.4	125.9	139.8	175.0	189.6	203.9
CDX4	.0	.0	100.4	117.8	.0	.0	.0	.0
CDX3	.0	.0	89.6	.0	.0	.0	.0	.0
CDXPTS	82.5	89.6	130.1	141.6	155.4	190.7	205.3	219.6
CDUDL	82.5	89.6	130.1	141.6	155.4	190.7	205.3	219.6
CC	81.3	88.4	132.7	144.2	158.1	197.2	211.7	226.0

Table 9—Wood costs by panel grade and thickness

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8
AAE	128.2	173.6	203.0	227.0	253.7	280.4	307.1	333.8
ABE	125.0	169.6	199.0	223.0	249.7	276.4	303.1	329.8
ACE	96.1	133.5	162.9	186.9	213.7	240.4	267.1	293.8
BB	121.8	165.6	195.0	219.0	245.7	272.4	299.1	325.8
BBO	121.8	165.6	195.0	219.0	245.7	272.4	299.1	325.8
BCE	92.9	129.5	158.9	182.9	209.6	236.4	263.1	289.8
AAI	128.2	173.6	203.0	227.0	253.7	280.4	307.1	333.8
ABI	125.0	169.6	199.0	223.0	249.7	276.4	303.4	329.8
ADI	96.1	133.5	162.9	186.9	213.7	240.4	267.1	293.8
BDI	92.9	129.5	158.9	182.9	209.6	236.4	263.1	289.8
CDX	64.1	80.1	106.8	133.5	160.2	186.9	213.7	240.4
CDX4	.0	.0	106.8	133.5	.0	.0	.0	.0
CDX3	.0	.0	106.8	.0	.0	.0	.0	.0
CDXPTS	74.8	93.5	122.9	146.9	173.6	200.3	227.0	253.7
CDUDL	74.8	93.5	122.9	146.9	173.6	200.3	227.0	253.7
CC	64.1	80.1	106.8	133.5	160.2	186.9	213.7	240.4

Table 10—Total costs by grade and thickness

	1/4-5/16	3/8	1/2	5/8	3/4	7/8	8/8	9/8
AAE	244.0	303.2	376.9	412.6	453.3	524.7	566.1	607.2
ABE	242.1	300.5	374.2	409.9	450.7	522.1	563.4	604.5
ACE	191.4	242.6	316.3	352.0	392.8	464.2	505.5	546.6
BB	231.9	289.5	363.2	399.0	439.7	511.1	552.5	593.6
BBO	231.9	289.5	363.2	399.0	439.7	511.1	552.5	593.6
BCE	188.7	239.1	312.8	348.6	389.3	460.7	502.1	543.2
AAI	242.1	301.3	371.2	406.9	447.6	515.2	556.6	597.7
ABI	240.2	298.6	368.5	404.2	444.9	512.5	553.9	595.0
ADI	187.6	238.8	308.7	344.4	385.1	452.7	494.1	535.2
BDI	184.9	235-3	305.2	340.9	381.6	449.2	490.6	531.7
CDX	130.9	154.0	221.3	259.4	300.0	362.0	403.2	444.2
CDX4	.0	.0	207.2	251.4	.0	.0	.0	.0
CDX3	.0	.0	196.4	.0	.0	.0	.0	.0
CDXPTS	157.3	183.1	253.0	288.4	329.0	391.0	432.3	473.3
CDUDL	157.3	183.1	253.0	288.4	329.0	391.0	432.3	473.3
CC	145.4	168.5	239.6	277.7	318.3	384.1	425.4	466.4

Table 11—Veneer volumes by thickness and grade

	1/10	1/8	1/6	3/16	TOTAL SM	TOTAL 3/8"
A	15223.	38995.			54217.	17058.
B	1349.	34194.			35543.	11758.
C-P	0.	0.			0.	0.
C	57396.	76750.	0.	61298.	195444.	71538.
D	59501.	49773.	0.	22643.	131917.	43779.
TOTAL	133469.	199712.	0.	83941.	417121.	144133.

Table 12—Costs by panel thickness

Table 12--Costs by panel thickness

	1/4-5/16	3/8	1/2	5/8	3/8	7/8	8/8	9/8
SANDED								
PONDYARD	2.9	4.2	5.5	6.6	7.8	9.0	10.2	11.4
DEBARKER	1.2	1.8	2.3	2.7	3.3	3.8	4.2	4.8
GREEN END	18.2	22.1	32.4	35.6	39.2	50.9	54.5	58.1
DRYING	15.4	22.2	28.8	34.5	41.8	50.5	57.8	65.1
LAYUP&PRESS	13.3	13.7	25.3	25.6	25.8	34.6	35.5	36.2
GLUING	7.5	7.5	14.9	14.9	14.9	22.4	22.4	22.4
TRIMMING	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
WAREHOUSE	1.6	2.3	3.1	3.7	4.3	5.0	5.7	6.3
SELLING	1.1	1.3	1.8	2.2	2.7	3.1	3.6	4.0
ROUGH								
PONDYARD	2.9	3.6	4.8	6.0	7.2	8.4	9.6	10.8
DEBARKER	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5
GREEN END	18.2	20.2	30.4	33.7	37.4	47.2	50.9	54.5
4-PLY	.0	.0	27.0	30.6	.0	.0	.0	.0
3-PLY	.0	.0	23.7	.0	.0	.0	.0	.0
DRYING	15.4	18.5	25.7	30.9	38.2	43.2	50.5	57.8
4-PLY	.0	.0	24.7	32.0	.0	.0	.0	.0
3-PLY	.0	.0	24.8	.0	.0	.0	.0	.0
LAYUP&PRESS	13.3	13.7	25.3	25.6	25.8	34.6	35.5	36.2
4-PLY	.0	.0	18.8	22.6	.0	.0	.0	.0
3-PLY	.0	.0	15.7	.0	.0	.0	.0	.0
GLUING	7.5	7.5	14.9	14.9	14.9	22.4	22.4	22.4
4-PLY	.0	.0	12.5	12.5	.0	.0	.0	.0
3-PLY	.0	.0	8.7	.0	.0	.0	.0	.0
TRIMMING	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
WAREHOUSE	1.6	2.0	2.7	3.3	4.0	4.7	5.3	6.0
SELLING	.8	1.0	1.3	1.6	2.0	2.3	2.6	3.0

Appendix E—Variable Names in LP Model

When modifying veneer requirement equations in LPFILE and LPMOD, the following variables can be used for panel names, log names, veneer conversion activity names, purchased veneer names, and by-product names.

Panel Names

The convention is to identify panels based on the grade of the veneer in the face and back (A, B, etc.), its glue type (I is interior, E or X is exterior), its thickness category (1/4, 1/2, etc.), and its level of profit (H is high or L is low). In the following, the H or L suffix is omitted.

Thickness (in.)	Grade									
	AA ext	AB ext	AC ext	BB	BBO&ES	BC ext	AA int	AB int	AD int	BD int
1/4	AAEX14	ABEX14	ACEX14	BBXX14	BBOX14	BCEX14	AAIX14	ABIX14	ADIX14	BDIX14
3/8	AAEX38									
1/2	.									
5/8	.									
3/4	.									
7/8	.									
8/8	.									
9/8	AAEX98	.	.	.	.	.	.	.	.	BDIX98
	CDX3-p	CDX4-p	CDX-5p	CDXPTS	Underlay	CC				
5/16	NA	NA	CDXX14	CDXP14	CDUDL14	CCXX14				
3/8	NA	NA	CDXX38							
1/2	CDX312	CDX412	CDXX12							
5/8	NA	CDX458	CDXX58							
3/4	NA	NA	.							
7/8	NA	NA	.							
8/8	NA	NA	.							
9/8	NA	NA	CDXX98	.	.	CCXX98				

Log Names

Peeled to (in.)	Log size			
	Small	Medium	Large	Extra large
1/10	SLOG10	MLOG10	LLOG10	XLOG10
1/8	SLOG08			
1/6	SLOG06			
3/16	SLOG16	.	.	XLOG16

Veneer Conversion Activity Names

Veneer thickness (in.)	B to A	B to C	C to B	C to D	C to P	D to C
1/10	YBA10	YBC10	YCB10	YCD10	YCP10	YDC10
1/8	YBA8	YBC8	YCB8	YCD8	YCP8	YDC8
1/6	NA	NA	NA	YCD6	NA	YDC6
3/16	NA	NA	NA	YCD16	Na	YDC16

Purchased Veneer Names

Veneer thickness (in.)	AB-grade	CD-grade
1/10	PAB10	PCD10
1/8	PAB8	NA
1/6	NA	PCD6

By-Product Names

Cores
Chips

Appendix F—Assumed Plywood Constructions

Table 13 gives the panel constructions used in computing unit cost for individual panels.

Table 13—Panel construction

Panel (in.)	Face (in.)	Back (in.)	Core (in.)	Center (in.)
		SANDED		
1/4	1/10	1/10	1/10	
3/8	1/8	1/8	3/16	
1/2	1/10	1/10	2-1/8	1/8
5/8	1/8	1/8	2-1/8	3/16
3/4	1/8	1/8	2-3/16	3/16
7/8	1/8	1/8	4-1/8	3/16
8/8	1/8	1/8	2-1/8, 2-3/16	3/16
9/8	1/8	1/8	4-3/16	3/16
		ROUGH		
5/16	1/10	1/10	1/10	
3/8	1/8	1/8	1/8	
1/2 3 ply	1/6	1/6	1/6	
1/2 4 ply	1/8	1/8	2-1/8	
1/2 5 ply	1/10	1/10	2-1/10	1/10
5/8 4 ply	1/8	1/8	2-3/16	
5/8 5 ply	1/8	1/8	2-1/8	1/8
3/4	1/8	1/8	2-3/16	1/8
7/8	1/8	1/8	4-1/8	1/8
8/8	1/8	1/8	2-1/8, 2-3/16	1/8
9/8	1/8	1/8	4-3/16	1/8

Appendix G— Printout of LP Results

A program called READ extracts the most important information from the file and arranges this information in a readable format. The following is a printout of LP results using the READ program.

SUMMARY LP RESULTS

PRODUCT MIX FOR_____ RUN
1000 sq. ft., SM

ABEX14H	52.1	ABEX14L	.0	ABEX14	52.1
ABEX38H	29.6	ABEX38L	.0	ABEX38	29.6
ABEX34H	231.2	ABEX34L	.0	ABEX34	231.2
ACEX34H	609.5	ACEX34L	.0	ACEX34	609.5
BCEX14H	15.1	BCEX14L	35.9	BCEX14	51.0
BCEX38H	5.2	BCEX38L	.0	BCEX38	5.2
AAIX34H	1.9	AAIX34L	.0	AAIX34	1.9
ABIX14H	32.3	ABIX14L	.0	ABIX14	32.3
ABIX34H	178.9	ABIX34L	.0	ABIX34	178.9
ADIX34H	141.5	ADIX34L	.0	ADIX34	141.5
BDIX14H	12.8	BDIX14L	.0	BDIX14	12.8
BDIX38H	7.5	BDIX38L	.0	BDIX34	7.5
BDIX12H	6.7	BDIX12L	.0	BDIX12	6.7
BDIX58H	.5	BDIX58L	.0	BDIX58	.5
BDIX34H	5.3	BDIX34L	7205.4	BDIX34	7205.4
CDXP58H	10.0	CDXP58L	.0	CDXP58	10.0
CDXP78H	12.0	CDXP78L	.0	CDXP78	12.0
CDXP88H	1.0	CDXP88L	.0	CDXP88	1.0

LOG PEEL ORDER (100 cubic ft)	1/10	1/8	1/6	3/16	TOTAL
SLOG	.0	178.6	.0	946.4	1125.0
MLOG	.0	.0	.0	.0	.0
LLOG	.0	1342.0	.0	.0	1342.0
XLOG	37.6	12.4	.0	.0	50.0
TOTAL	37.6	1533.0	.0	946.4	2517.0

VENEER PURCHASED (MSM)			
AB	179.3	3500.0	
CD	.0		.0

VENEER CONVERSION (MSM)				
BA	2.4	.0	.0	.0
BC	.0	.0	.0	.0
CB	.0	4859.8	.0	.0
CP	.0	23.0	.0	.0
CD	.0	4949.3	.0	.0
DC	.0	.0	.0	652.3

UNUSED MACHINE CAPACITY (HRS)	
LATHE	188.8
DRYER	642.4
PLUGGER	.0
PRESS	.0
NET PROFIT ($1000)	2360.3

ITEMIZED COSTS ($1000)	
LOGS	145.0
PLUGGING	50.5
VENEER	167.5

OUTPUT (MSF 3/8")	
SANDED	16941.0
ROUGH	47.3
TOTAL	16988.4

MARGINAL VALUE

VENEER	1/10	1/8	1/6	3/16
A	83.0	88.0	.0	.0
B	44.4	58.0	.0	.0
C	5.2	8.5	11.8	13.4
D	1.0	.0	.0	.0

LOGS	SLOGS	MLOGS	LLOGS	XLOGS
	6.1	.0	.0	35.4

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